Squirm and lateral Wander in Certain Textures

A Case Study of Diagnosis and Mitigation

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Research Pays Off Seminar Series
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Squirm Versus Lateral Wander

Squirm

- **Dictionary**: Wriggle or twist the body from side to side, especially as a result of nervousness or discomfort.
- **Engineering:** A forced vehicular orientation in the path of motion in the direction of traffic by the texture.

- Short lived and goes away with traffic
- Uninformed correction can be expensive

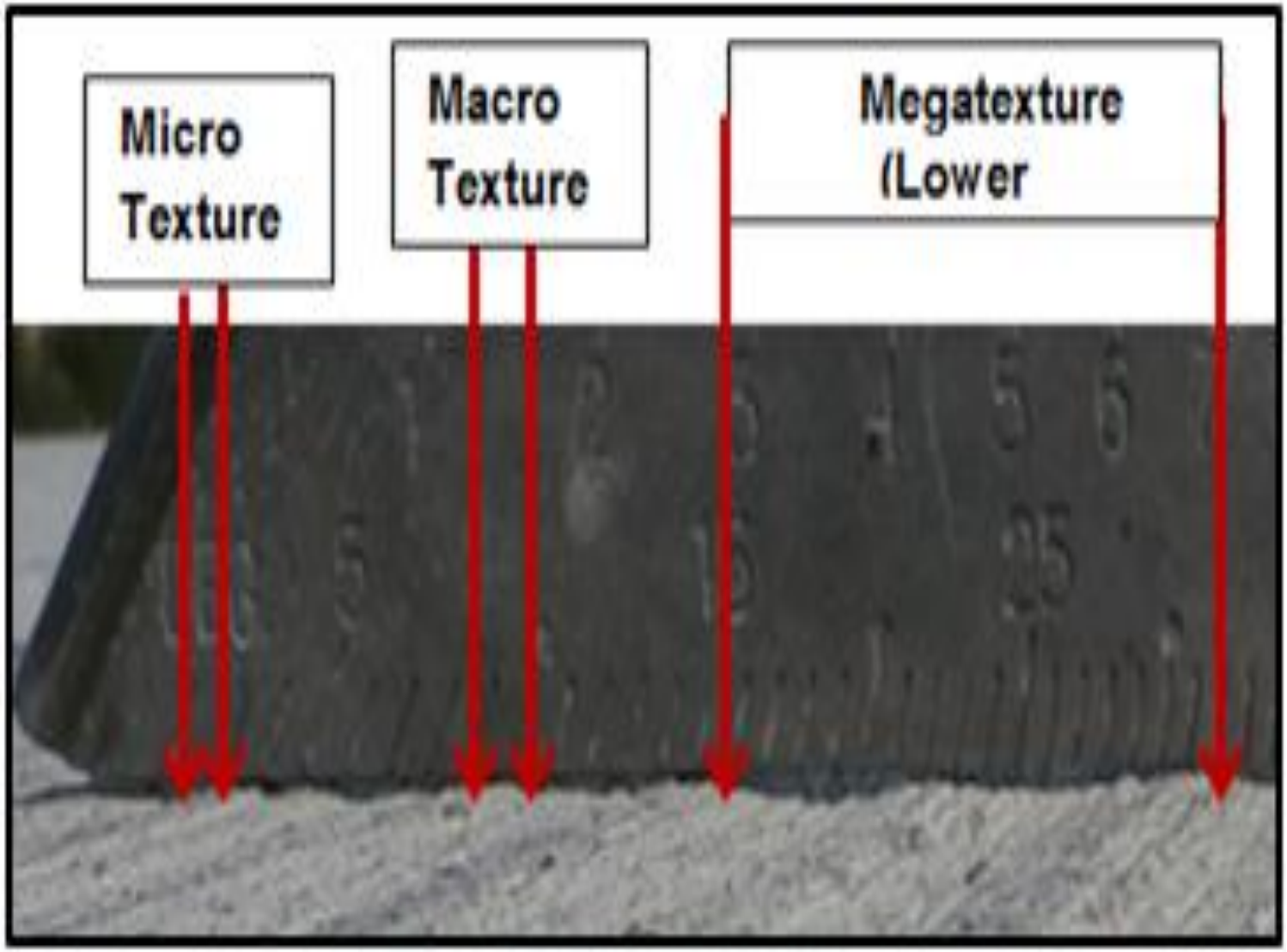
Squirm Versus Lateral Wander

Lateral Wander

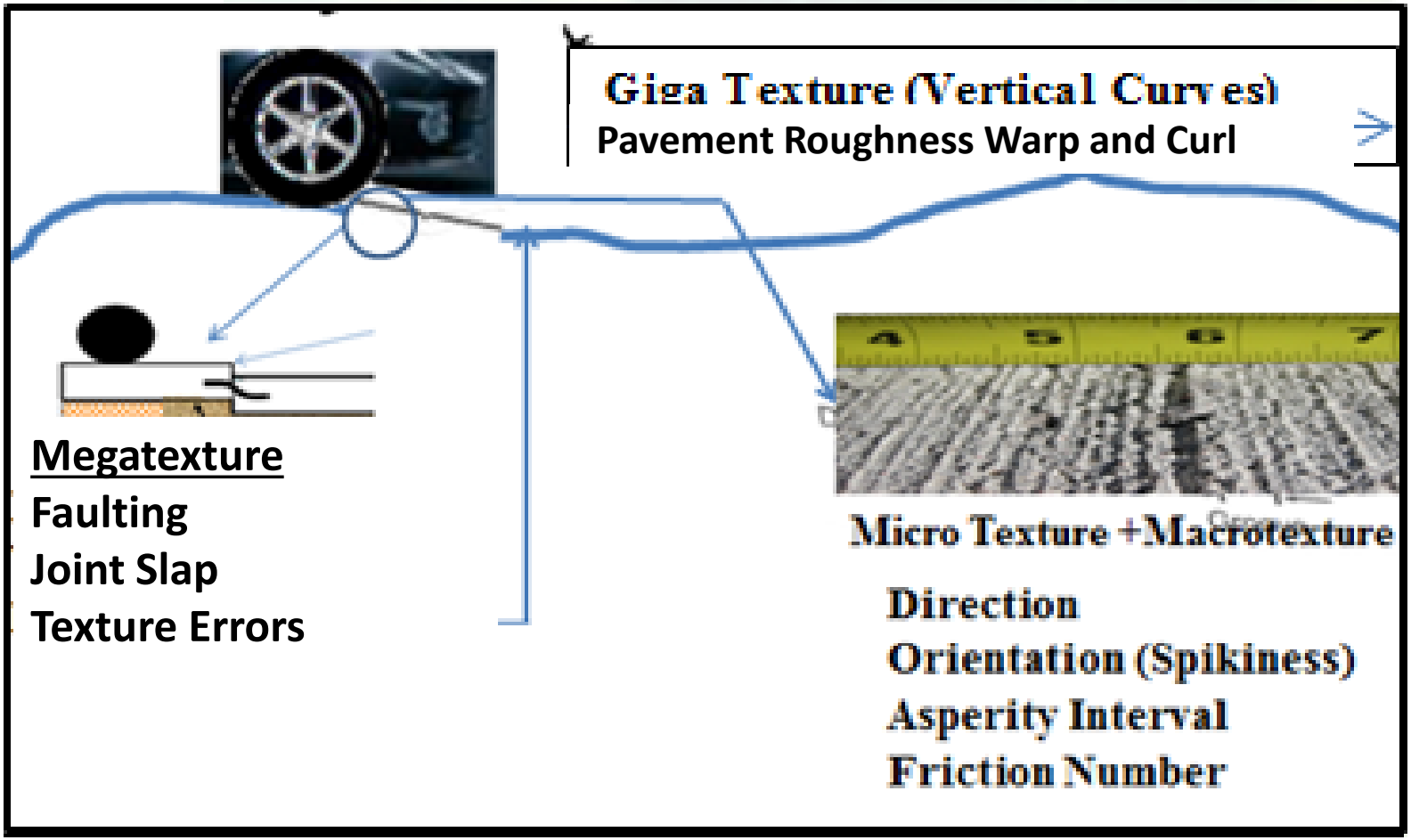
- **Dictionary**: Wriggle or twist of body from side to side from preferred or prescribed direction.
- **Engineering**: A Forced Orientation off the Path of Motion or Texture or the Direction of Traffic by Texture Anomaly. Associated with spontaneous self steer.

- Not Short lived and gets worse with Time & Traffic
- Very Unsafe
- Must be mitigated very quickly and expensively

Texture Categorization 101



Texture Fundamentals

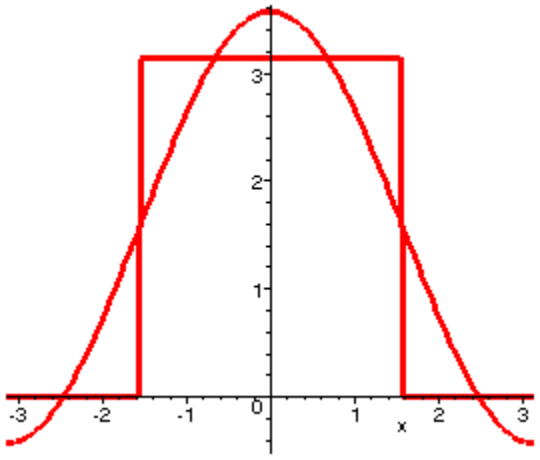


Orders of Magnitude cannot be ignored

Texture Categorization

Range	Texture Wavelength	Typical Amplitude	Remarks
Micro	< 0.5 mm (<0.002”)	<0.001mm (<4.0E-5”)	Feels harsh but invisible to the naked eye necessary for adhesion friction
Macro	0.5-50 mm (0.002” -2”)	0.1-20 mm (0.004” -0.8”)	Important for tire interaction being of same order of magnitude as tire configurations
Mega	50 mm-500 mm (2” -20”)	0.1-50 mm (0.004”- 2”)	Wavelength similar to tire pavement contact patch and larger can cause wander
Giga	>500 mm (> 20 “)	>50 mm (> 2”)	Warp and Curl, Faulting interval Panel warp &Curl, vertical curves (Ride Quality)

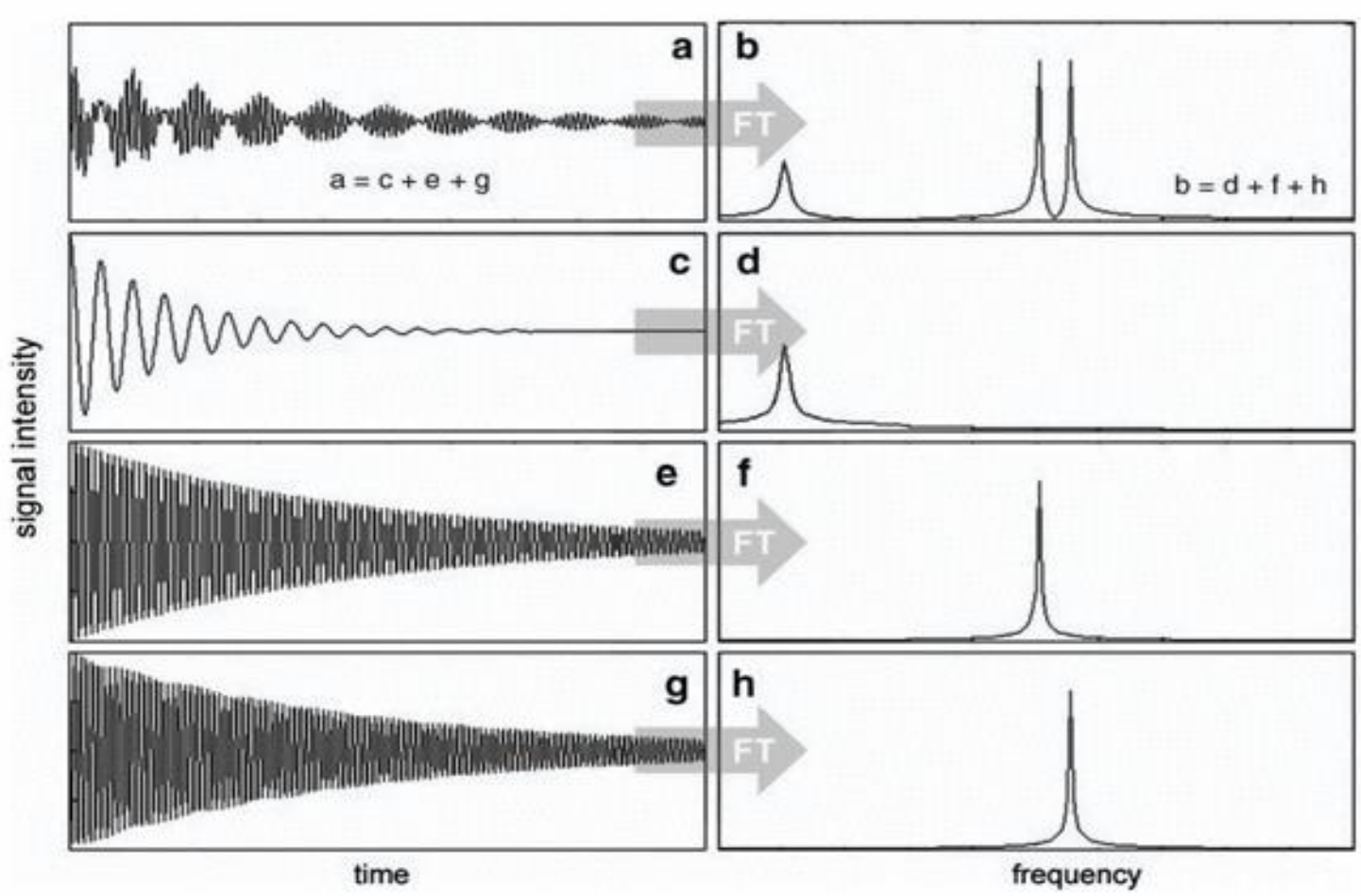
CHAOS IS EASY TO MODEL



AS FOR MODELING OF ORDER: Fourier transform of impulsive Function Spatial to Frequency Domain (Keep Your Enemies Even Closer)

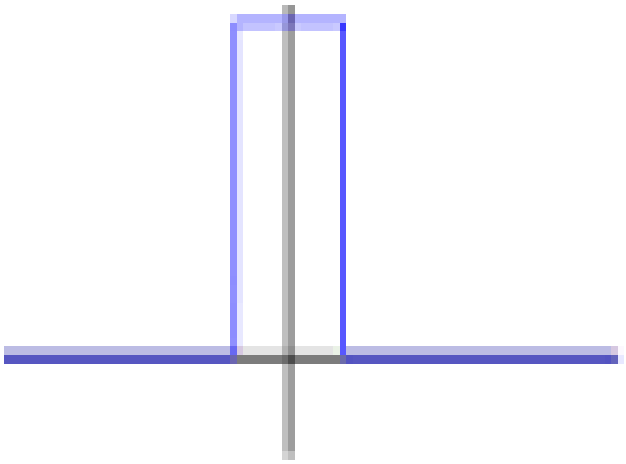
CHAOS CAN BE MODELLED: Soccer Leg Locus
(Keep your Friends Close)

Spatial Vs Frequency Domain

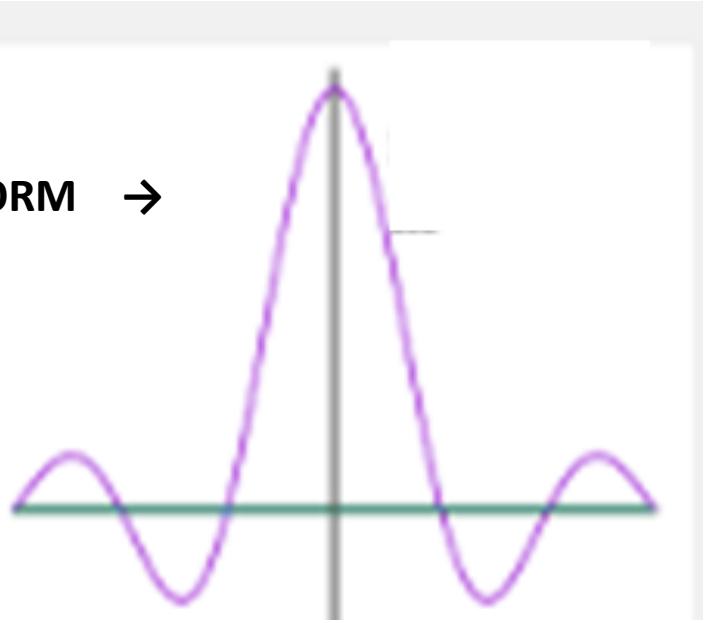


See from a Tire Perspective

What Does the Tire See?



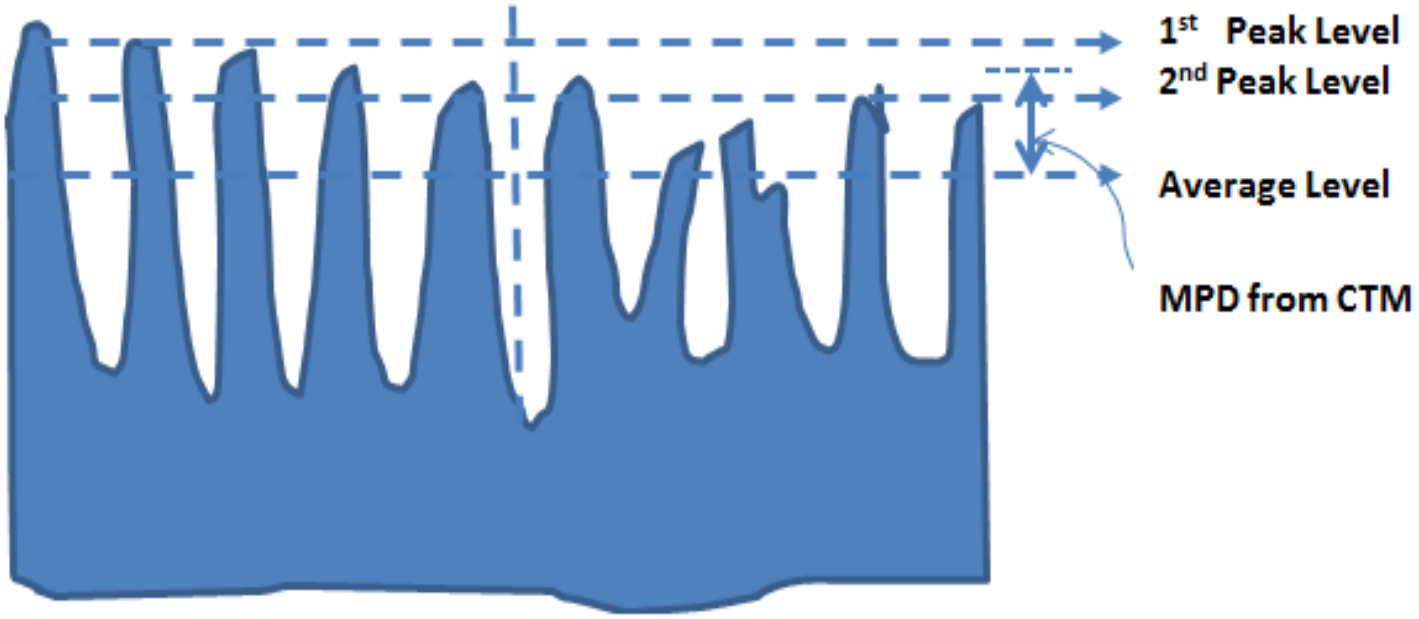
FOURIER TRANSFORM →



SPATIAL DOMAIN

FREQUENCY DOMAIN

Mean Profile Depth Vs Sand Path Texture Depth



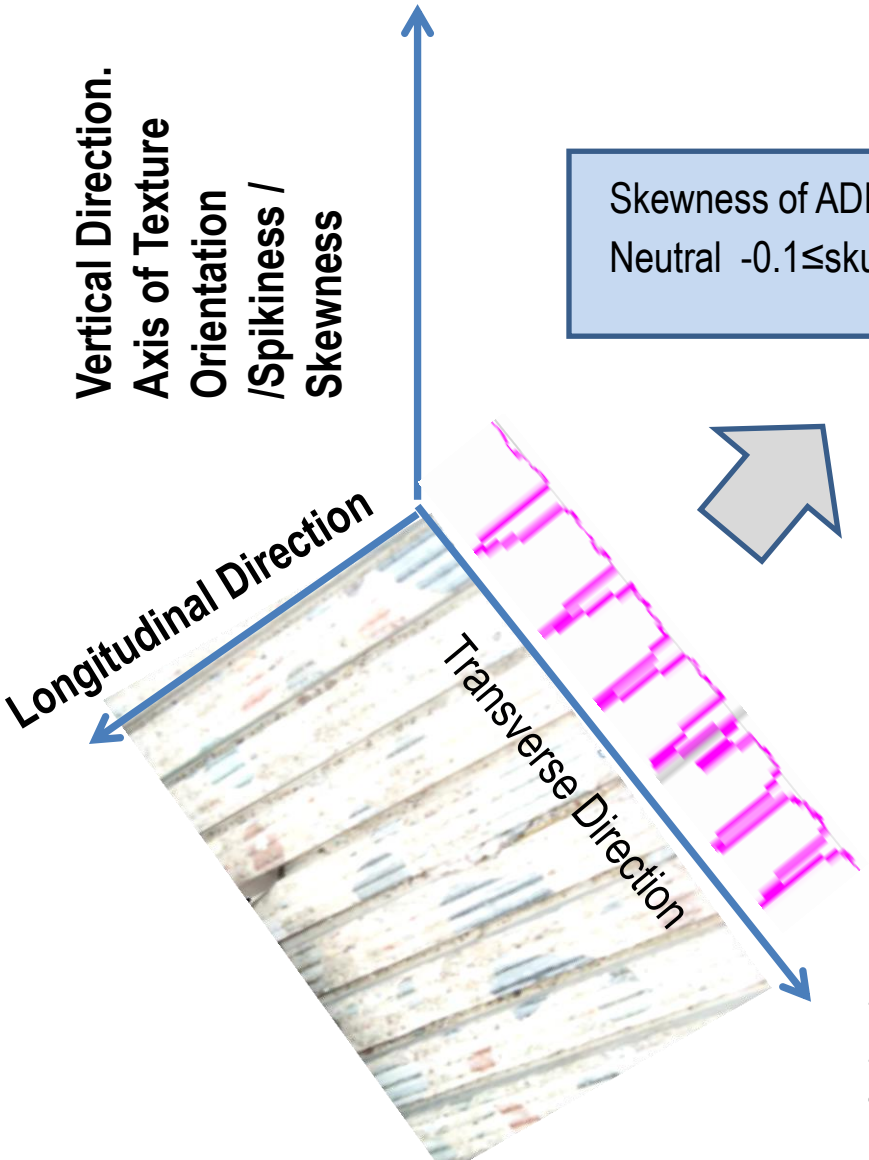
$$\text{MPD (from CTM)} = \frac{(\text{1st Peak Level} + \text{2nd Peak Level})}{2} - \text{Average Level}$$

$$\text{ETD from Sand Patch} = 0.2 + 0.8\ \text{MPD}$$

Coefficient of Determination is 97%

News Flash: Mean Texture Depth is Not an Engineering Quantity

Texture Orientation
A Vital Pavement Performance indicator



Skewness of ADF = SKu. Negative (<0.1)
Neutral -0.1≤sku≤ 0.1or Positive (Sku>0.1)

PARSER
SOFTWARE

OUTPUT

Texture orientation or Spikiness

APPLICATION

- **Noise Prediction**
- **Friction Prediction**
- **Rolling Resistance Association**

Relevant Sector From CTM Plot

ASP= Asperity Interval or ASPGW=Asperity Groove Width were found to be Significant Variables **Izevbekhai 2012**

CASE STUDY: SP 2480-104 INTERSTATE 35 UNBONDED OVERLAY PROJECT FROM MNTH 30 TO SOUTH OF MN TH 251

Lateral Wander Observed

- Significant in Small vehicles
- Relative Steer between Front and Back Axle induced at the Rear

Texturing;

- Broom With Undulating Ripples of higher Order of Magnitude
- CDG MPD= 0.9mm
- Broom MPD= 0.63
- Broom MPD Reported by Contractor = 0.9 (Before Blading)

Objective:

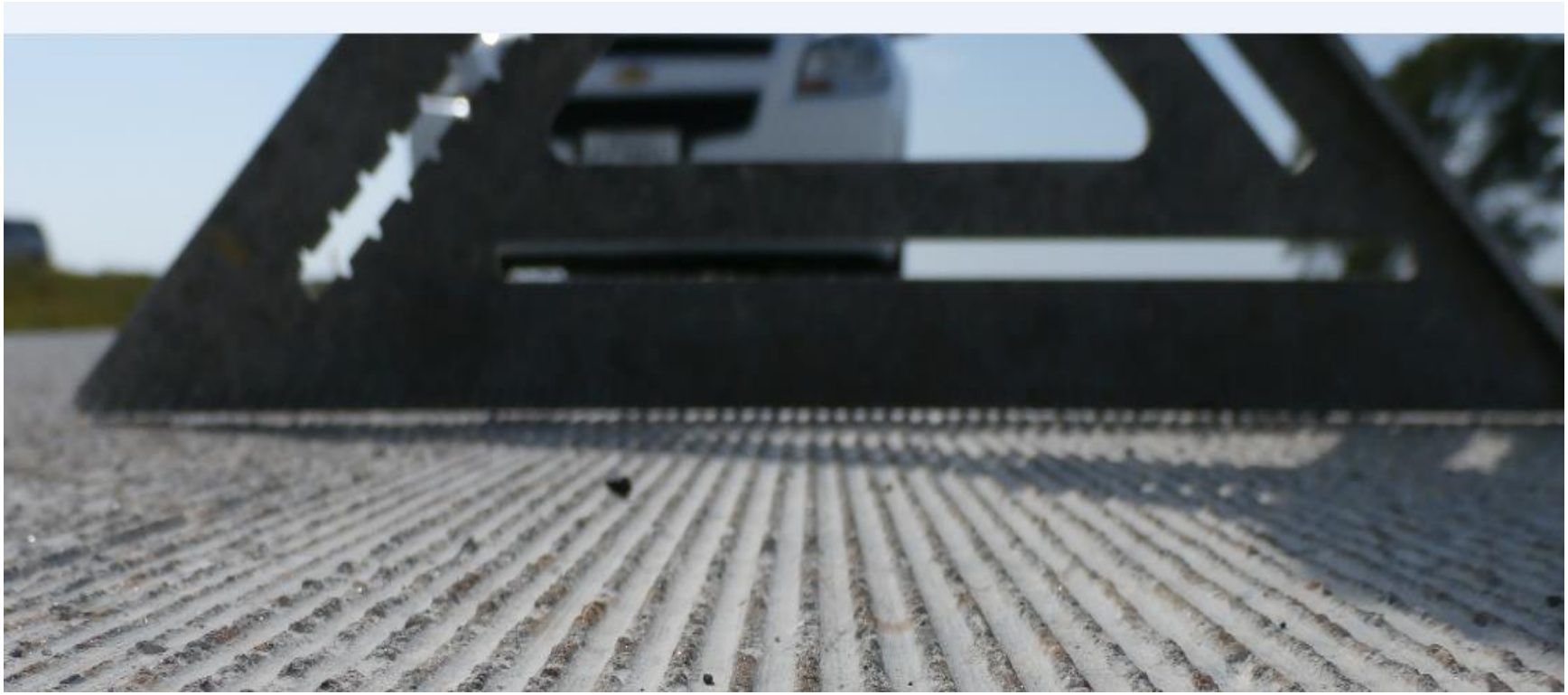
- Conduct tests to ascertain the cause of this low lateral skid resistance and to facilitate recommendations.

Research Design

- Null Hypothesis: Lateral Wander is not associated with Uneven Higher Order Wavelengths in this Project
- Evaluate the texture using various technologies to ascertain what characteristics may be associated with the unsafe conditions.
- Investigate Surface at various orders of Magnitude
    - Micro and macro Texture
    - Megatexture
    - Gigatexture
- Check for uniformity
- Analyze the results obtained.
- Draw plausible tenable inferences

Visuals: Envelopment Theory

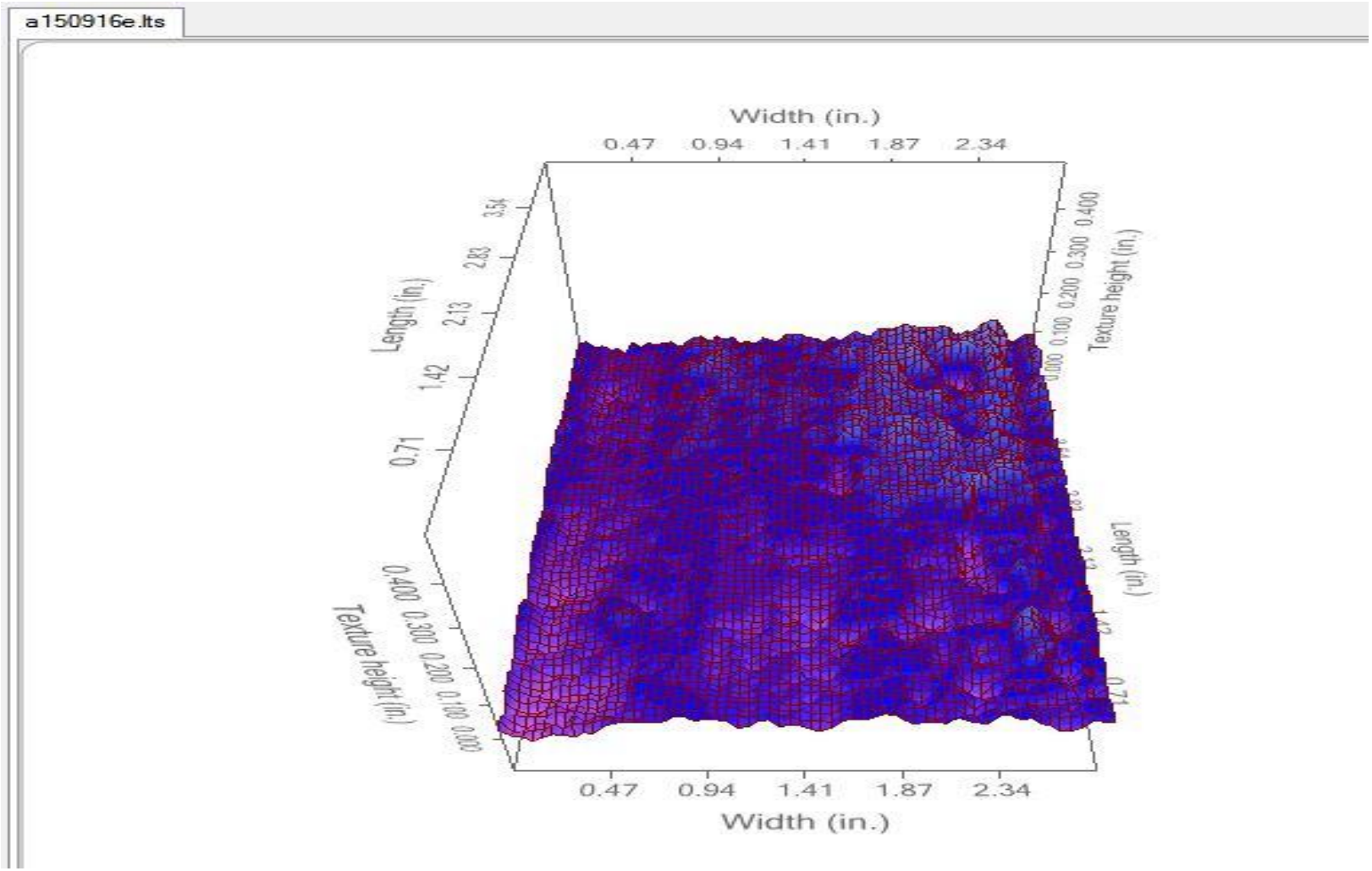
Diamond Grind Envelopment



Micro Texture and MacroTexture

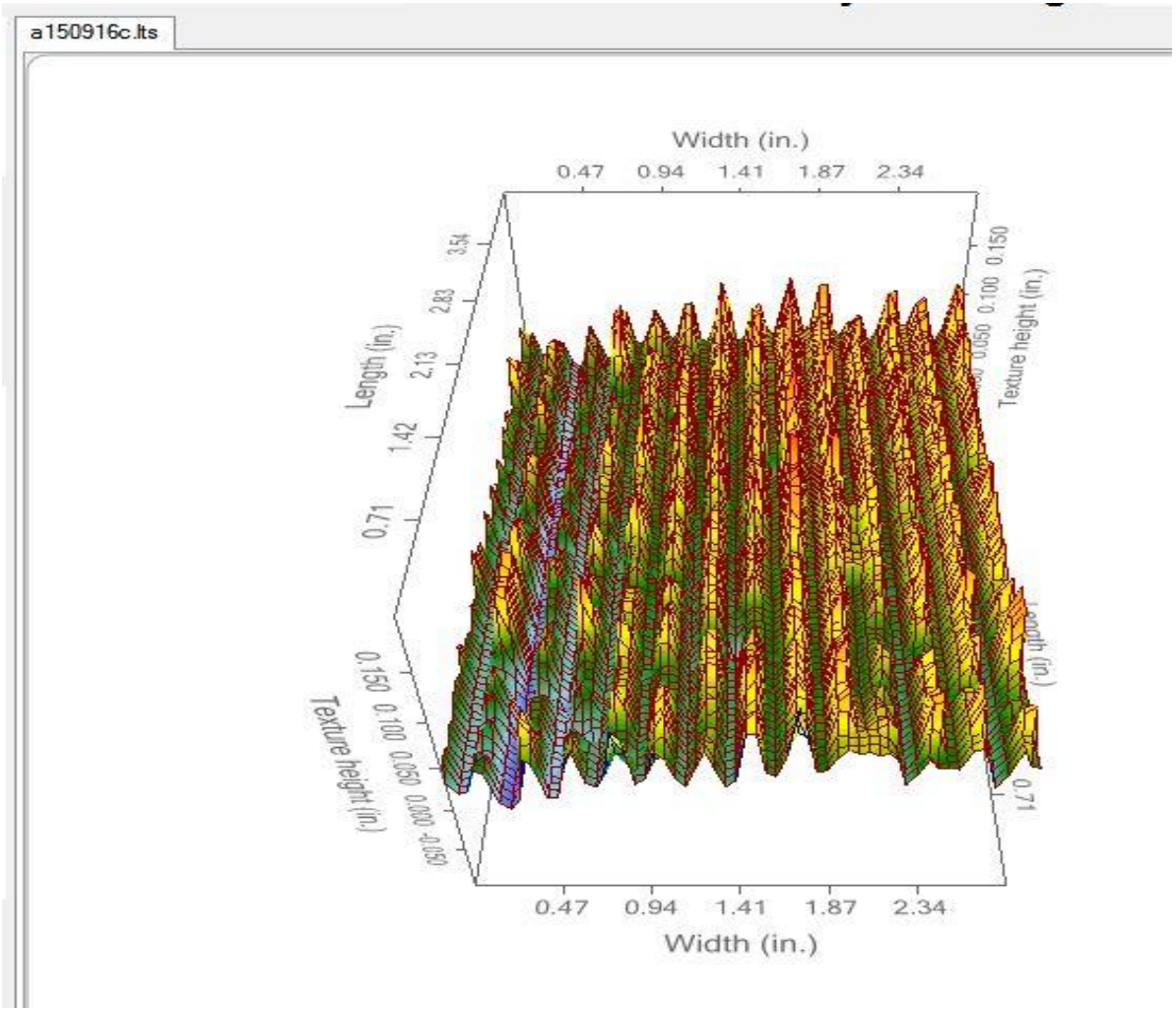
Ames Texture Imaging Scanner

SNAPSHOT FROM TEXTURE SCANNER



Drag

SNAPSHOT FROM TEXTURE SCANNER



Grind

Micro texture

- **<u>The Circular Track Meter (ASTM E-2157)</u>**:

Strange Observation

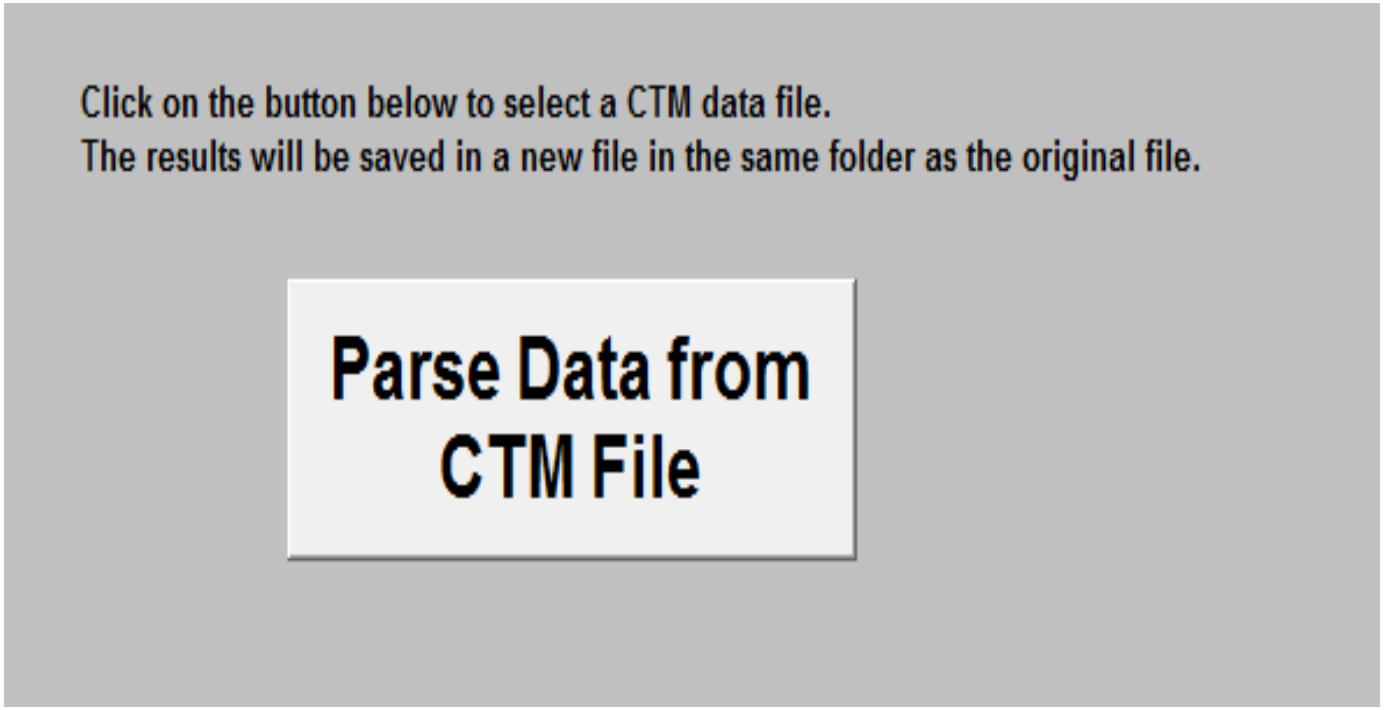
- Broom drag texture had a negative texture which is unusual unless it was bladed after paving.
- Conventionally Diamond ground section exhibited a neutral to positive texture orientation as expected

$$\text{Skewness or Texture orientation} = \frac{\sum_{i=1}^{N}(Y_i - \bar{Y})^3}{(N-1)S^3}$$

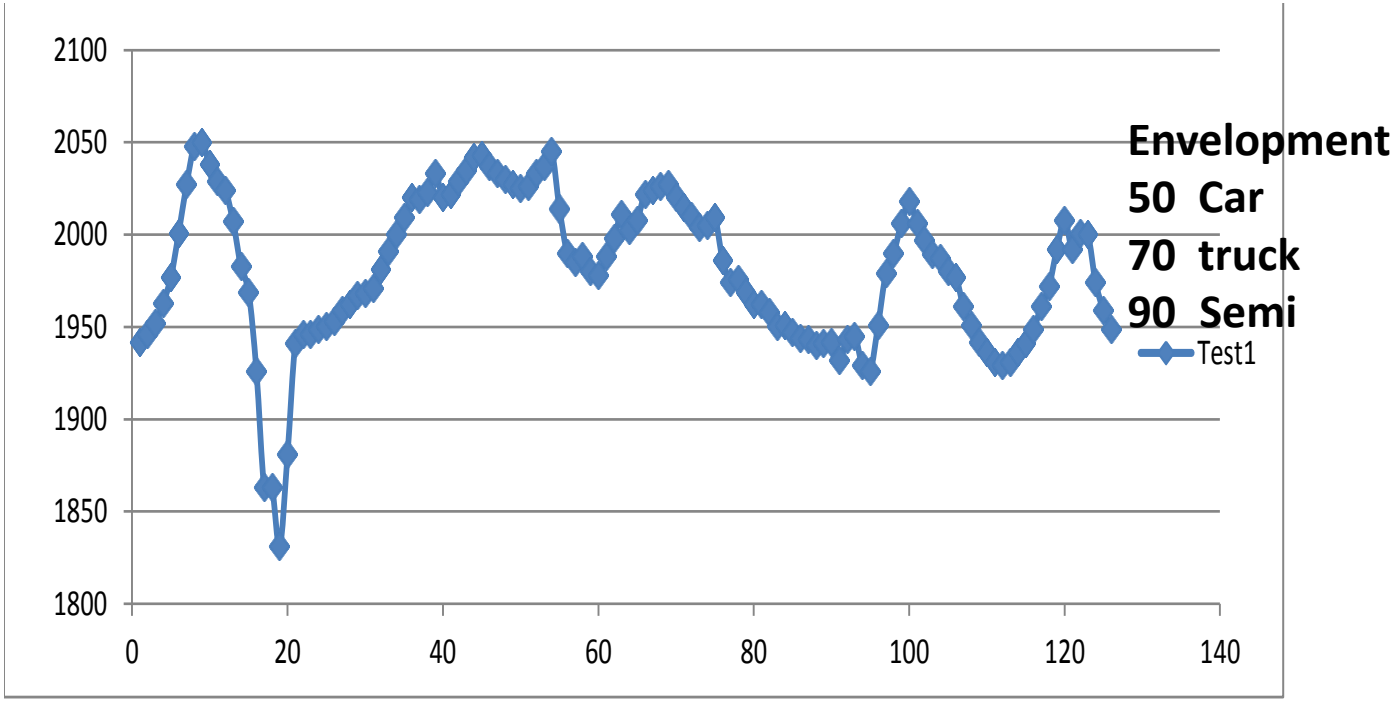
where Y = depth measured from reference
N = Sample size
S = Sample standard deviation

Izevbekhai, Wong & Ig-Izevbekhai (2015)

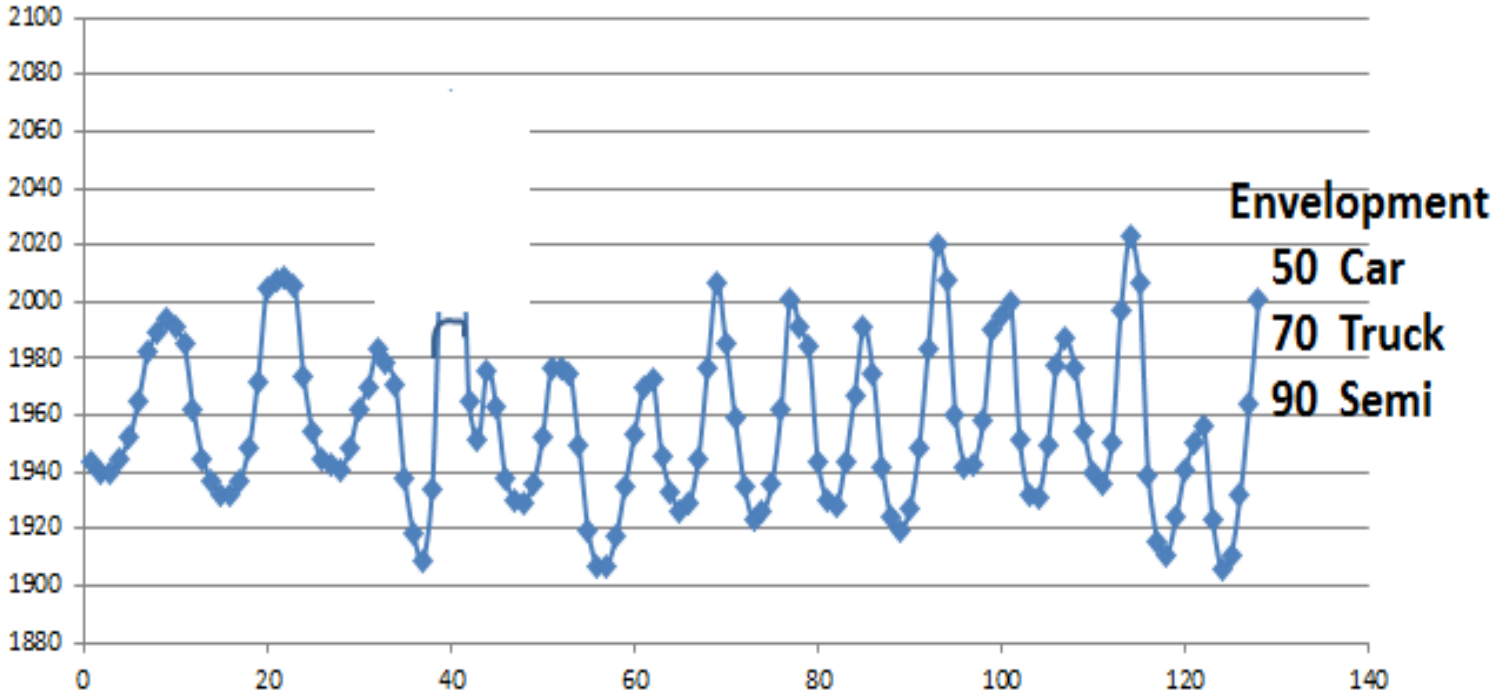
Texture Wavelength & Skewness



Mega Texture Intercalation



Diamond Grind Envelopment



Envelopment Theory Hamet & Klein 2001

Negative Texture Observed

Section	Location	Lane	Wheelpath	MPD	RMS	Remarks
1	1	DL	Rwp	0.47	0.28	Negative Texture Orientation
1	2	DL	Cl	0.5	0.31	Negative Texture Orientation
1	3	DL	Lwp	0.51	0.21	Negative Texture Orientation
1	4	PL	Rwp	0.88	0.45	Negative Texture Orientation
1	5	PL	Cl	0.68	0.37	Negative Texture Orientation
1	6	PL	Lwp	0.8	0.42	Negative Texture Orientation
1	7	DL	Rwp	0.49	0.27	Negative Texture Orientation

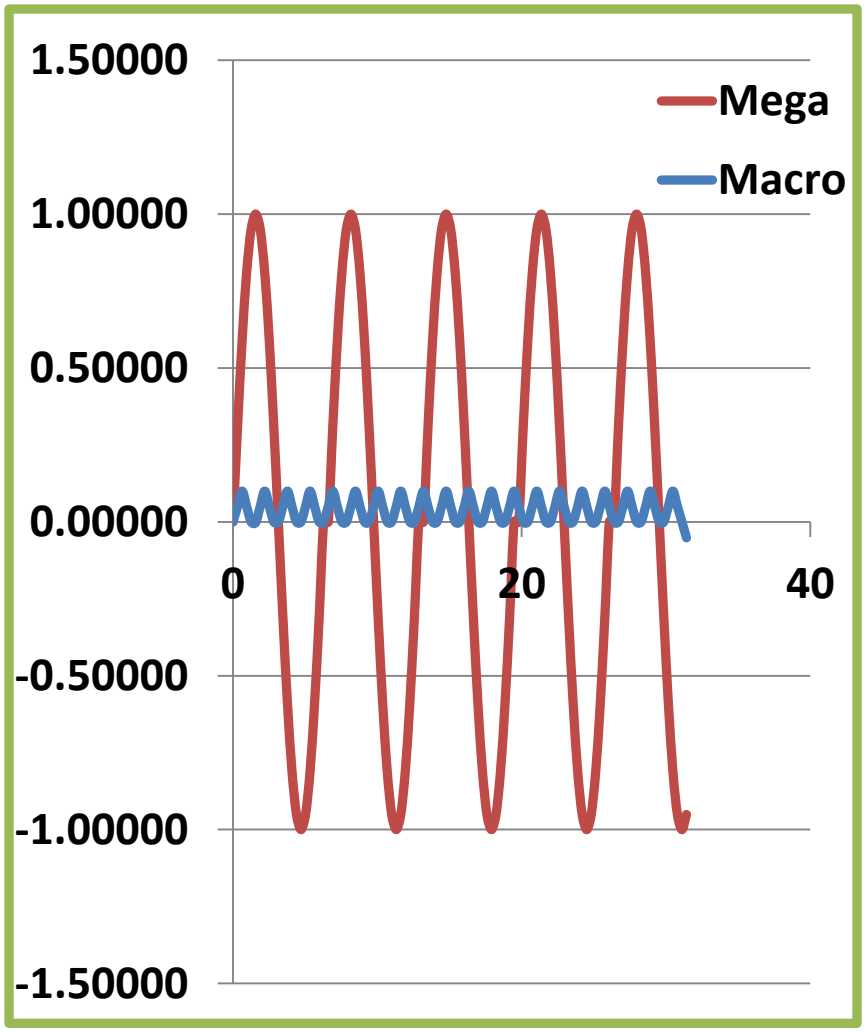
Other Observations

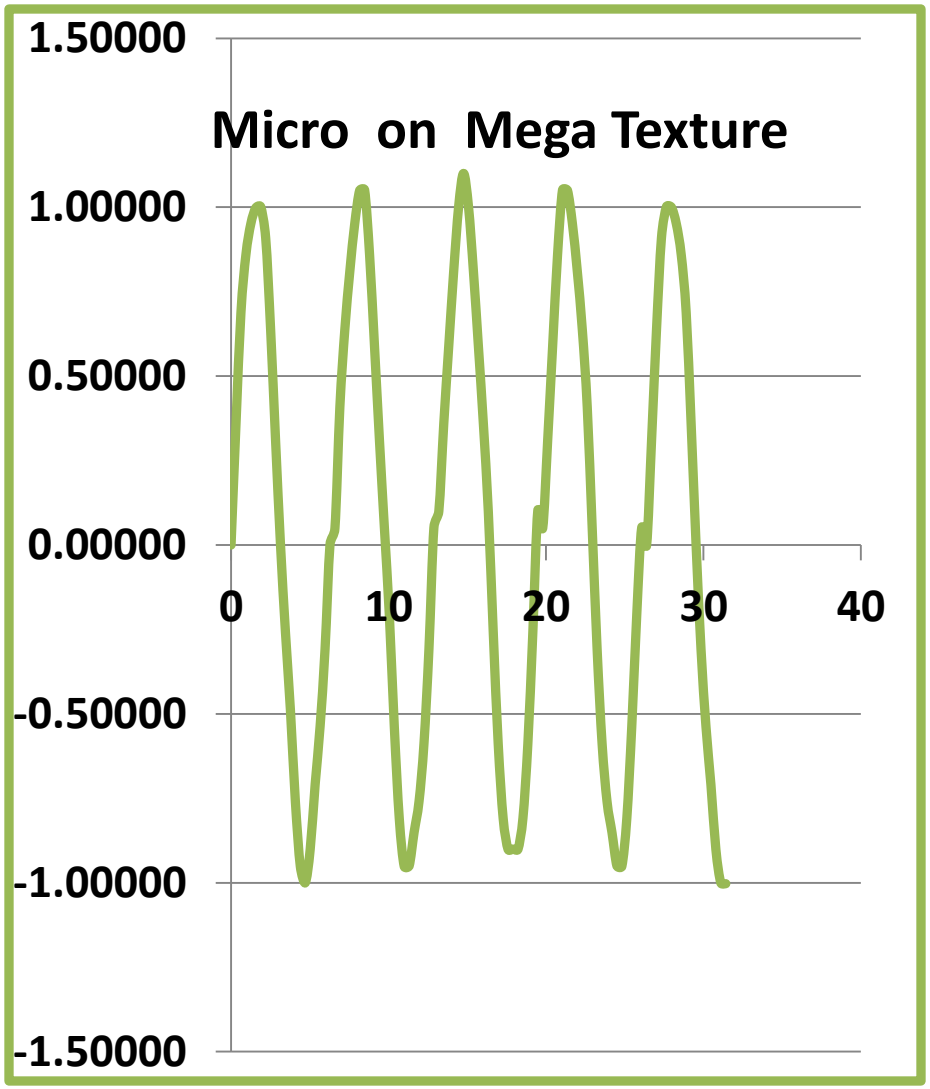
A Megatexture of wavelengths between 25 mm to 75 mm was observed in the broom dragged section, corroborating the visual observation of true megatextures on which the macro textures had been established. The danger of such megatexture lies in the inhibition of tire contact with the macro texture and an effective reduction in adhesion and hysteretic friction.

GIGATEXTURE Investigation

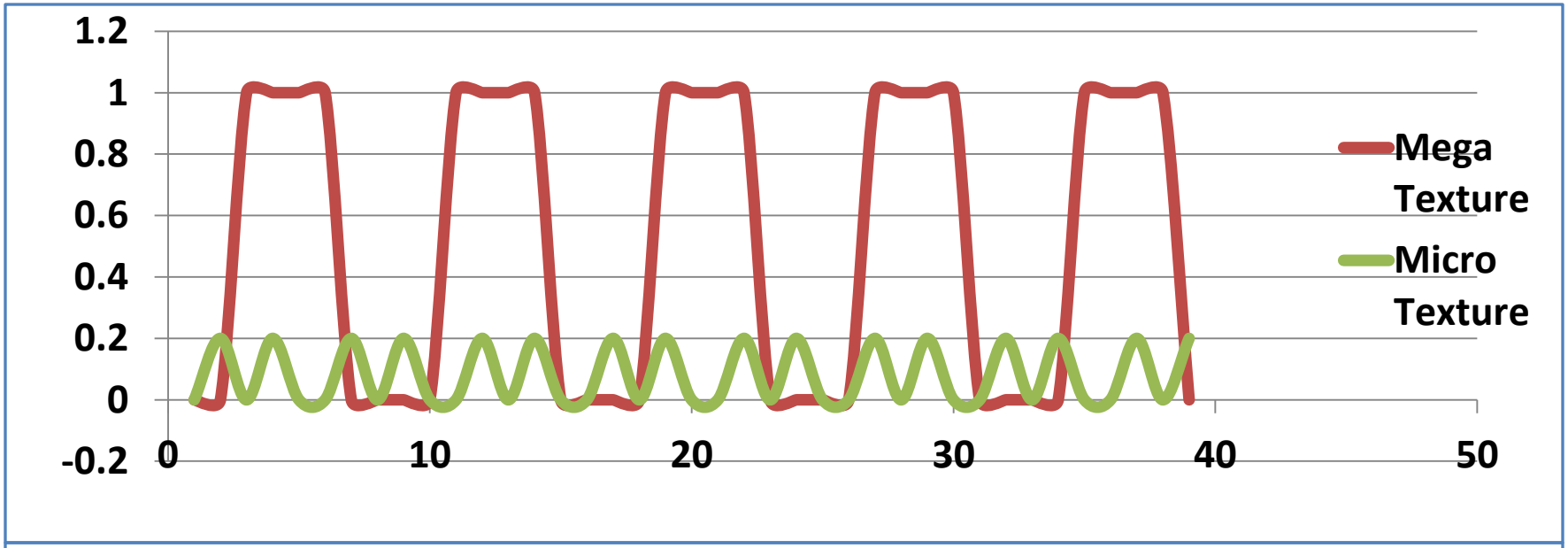
Warp and Curl showed Kink in the transverse profile at the wheel path otherwise on giga scale there was no red flag.

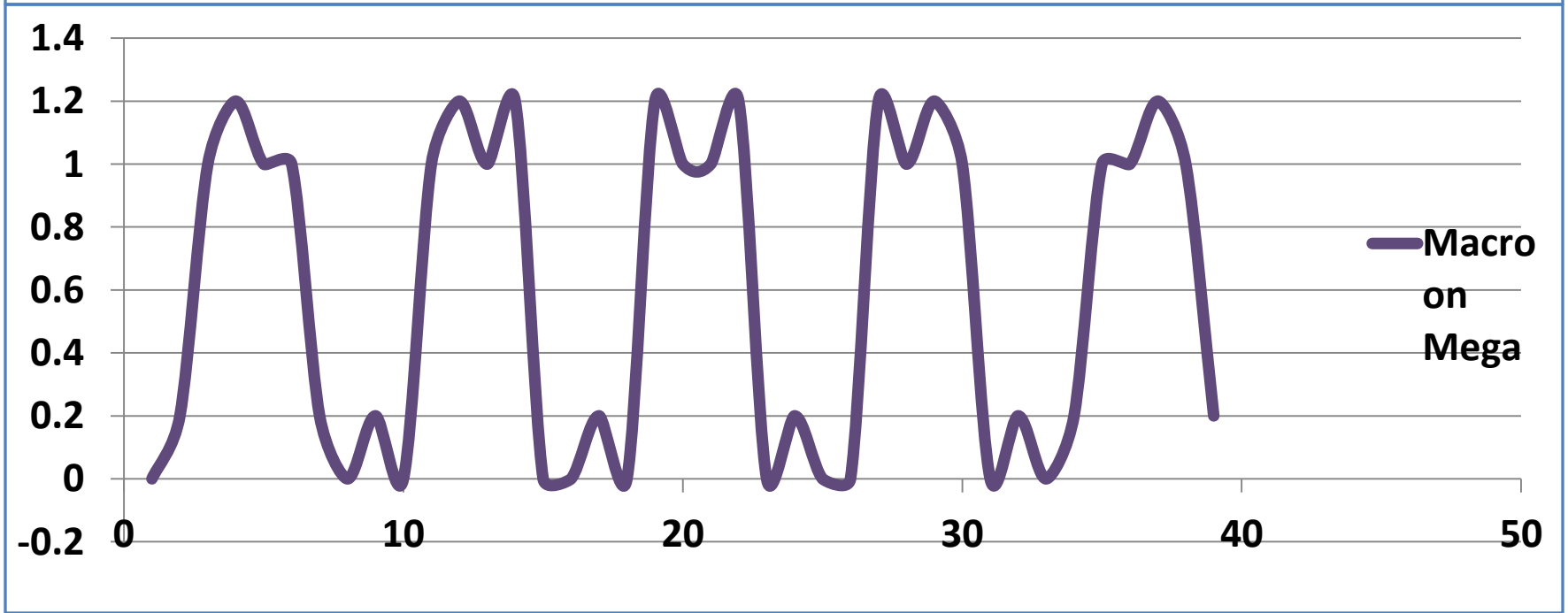
Diagnosis:Macro on Mega: Geometrically Similar





Diagnosis: Macro on Mega Texture: (Geometrically Dissimilar)





Remedy in Case Study

- Remove the mega Texture that inhibits envelopment.
- Performed Conventional Grind of Entire Cross Section
- Investigate Possible language to avert reoccurrence.

MINIMIZING LATERAL WANDER OCCURRENCE

- A friction spec Is not sufficient
- A texture depth spec is not even sufficient
- Absence of Lateral wander is required. Additionally an X inch long straight edge must make contact with at least “Y” % of the intervening asperities at the wheel track.

- No single gap between contacting asperities shall be greater than “Z” inch. The engineer may elect how much failure percentage is acceptable per lot not more than 7% is suggested.

- A Simple Device…

Lasting Solution

- Specification Language
- Avoidance by compliance to best practices
    1. No strange broom set up
    2. Use turf drag
    3. Pretextured Longitudinal Tining
- Avoidance by early detection
- Proper use of a straight edge
- Invention of a laser or other envelopment device

Acknowledgement

- Field Testing was performed by Steve Olson and Gordy Bruhn
- Investigation was requested by Maria Masten and Curtis Turgeon.
- Dave Van Deusen acting manager at that time signed my time sheet

QUESTIONS